

Ontology Management and Ontology Reuse in Web Environment

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Abstract. As a kind of knowledge representation method, ontology describes knowledge and information semantically in various fields and it has been widely used in Web environment. Ontology management and ontology reuse can solve the problems of knowledge confusion and inefficient knowledge base construction when applying ontology. This paper builds an ontology management framework and presents the system data storage model, ontology maintenance method and role-based ontology collaborative definition method. On this basis, an ontology reuse method based on Semantic Web Rule Language (SWRL) rule is proposed.

Keywords: Ontology management · Collaborative definition · Ontology reuse · SWRL

1 Introduction

Currently, the Internet has become an important way for people to obtain information. With the rapid development of intelligent equipment and information technology, the amount of information is growing exponentially, traditional data processing methods can only verify the huge data from the format level, but the problem of knowledge level verification remains a bottleneck.

As a kind of knowledge representation method, ontology describes knowledge and information semantically in various fields which can be identified and processed by the computer, so that integration and sharing of the data from different applications become possible. In the medical domain, Chmielewski et al. realized the integration and migration of medical data based on ontology [1]. In the manufacturing field, Qiao et al. proposed a process modeling method based on ontology and process specification language [2], Huang et al. built the ontology model of assembly process planning based on ontology [3]. Therefore, ontology has been widely used in the semantic Web. But with the continuous expansion of ontology needs in various fields, the number of Web ontologies has also grown substantially. On one hand a concept in the same field of different ontologies may be described differently. On the other hand, the same field has more than one ontology to repeatedly describe the same concept, which leads to knowledge confusion and redundancy as well as the lack of standardized management.

In addition, manual creation of domain ontology poses a high requirement for the proficiency of the creator in ontology technology and domain knowledge, and the creation process is dull and inefficient. Reusing existing ontologies can reduce the system cost, improve efficiency of knowledge base construction, and reduce the workload and the cost structure. Therefore, how to build and standardize the domain ontology and realize the reuse of ontology in Web environment becomes a hot research topic.

In ontology management, Domingue et al. developed the WebOnto system to support the creation and editing of ontology in Web environment. After the installation of the WebOnto client, users can learn and edit ontology, view ontology relations, classes and rules, etc. [4]. Walisadeera et al. developed an agricultural field of user-centered ontology management system. Users and developers can edit ontology in the system, modify the structure of the ontology, search information in the context of ontology, share and reuse knowledge, and achieve large-scale ontology based Web development and maintenance purposes [5]. Buranarach et al. described an ontology application management (OAM) framework that aims to simplify creation and adoption of ontology-based application which is based on the Semantic Web technology. The framework focuses on providing reusable and configurable data and application templates, which allows users to create ontology without required programming skills [6].

In ontology reuse, Pan et al. proposed a brand new way for partial ontology reuse. It supports Tbox reasoning in simple ontology spaces, where an ontology semantically imports vocabulary from another ontology [7]. Xiang et al. developed OntoFox system, which supports ontology reuse and expansion. Users can dynamically extract ontology without the proficiency in any SPARQL Protocol, RDF Query Language (SPARQL) or other programming techniques [8]. Caldarola et al. put forward the technology for ontology reuse method based on matching of heterogeneous, which improves and simplifies the process of ontology constrain by automating the selection and reuses existing data models to support the creation of digital ecosystems [9].

Considering the two problems above, this paper builds a framework of ontology management system, and puts forward a mechanism based on the definition of role collaboration. On this basis, a new idea of ontology reuse based on SWRL rule is provided.

2 Ontology Management in Web Environment

Ontology management not only collects ontologies in a large variety of fields under the semantic Web. It takes into account the correctness, extensibility, interoperability and reusability of ontology. According to the need for sharing and exchanging information in each domain, the ontology management framework is built as shown in Fig. 1.

The system framework consists of data layer, application layer and presentation layer. The data layer comprises a relational database and an ontology document library, and provides data support for the management system. The application layer includes domain ontology partition, ontology file upload analysis as well as ontology building and maintenance mode. In this way, it ensures the correctness of the logic relationship between the ontology classes and object properties and data properties. The presentation

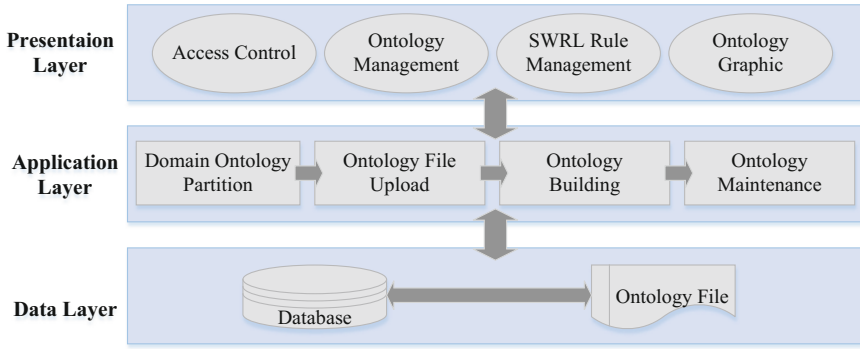


Fig. 1. Framework of ontology management system

layer consists of ontology and rule management, ontology visualization and authority control. Users can realize the learning of ontology and the reuse of ontology by reasonable human-computer interaction interface.

2.1 The Mapping Mode of Ontology and Database

Under the premise of satisfying the traditional pattern design principle, this paper parses the ontology by using Web Ontology Language (OWL) API. The OWL ontology storage mode is designed as shown in Fig. 2.

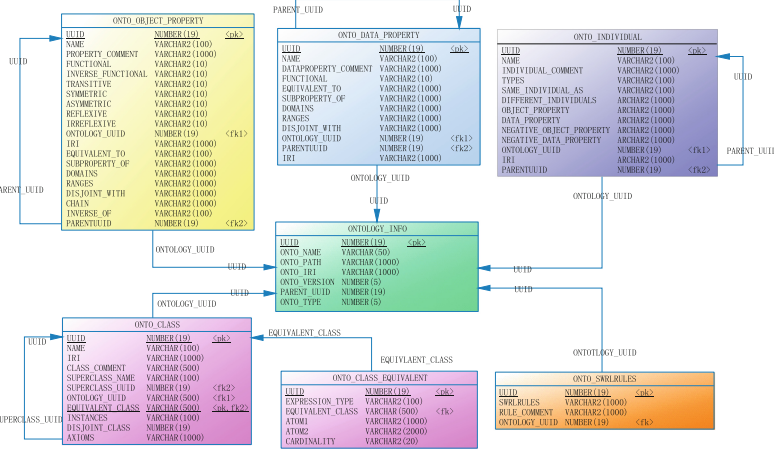


Fig. 2. Ontology storage mode

- Table ONTOLOGY_INFO stores the basic information of the ontology, including the name of ontology, ontology storage path, ontology Uniform Resource Identifier (URI), ontology version and other information.
- Table ONTO_CLASS_EQUIVALENT and table ONTO_CLASS store the information of ontology categories, including the name of the class, URI, annotation, disjoint classes, equivalent classes and other similar information.
- Table ONTO_DATA_PROPERTY and table ONTO_OBJECT_PROPERTY store the object property information and the data property information respectively. Including the basic property description such as the name of property, URI, annotation, equivalent property and domains etc. as well as the feature description such as functional, inverse functional, transitive, etc.
- Table ONTO_INDIVIDUAL stores individuals of ontology, including name, annotation, URI, class assertions, same individuals, object property declarations and data property declarations.
- Table ONTO_SWRLRULES stores the SWRL rules of ontology, including the rules and rules of the annotation itself.

It can be seen from the description above that the mode is simple in structure and easy to understand. It can clearly describe the relationship between the concepts. The mode structure is stable, so that when domain changes, there is no need to modify the table structure, the mode can be stored in various fields of ontology.

2.2 Ontology Maintenance Method

Ontology resources, such as classes, object properties, data properties and individuals in Ontology, all have their own URI. Describing the rule declaration to an ontology by using SWRL also can be regarded as a kind of resource of Ontology. When modifying or deleting five kinds of resources mentioned before, it is important to note that modifying or deleting a resource is not just a simple single resource modification or deletion, but all the resources that are related to the resources or resources properties to be modified or deleted in the ontology would be changed.

Therefore, resource attribute of five resources may be associated with the change, as shown in Fig. 3. The upper or the right side of the arrow are the properties that point to the possible change of the associated resource.

For instance, deleting a class may involve the parent class property, equivalent class property and disjoint class property of other classes in the ontology information change. It also may be associated with the properties of the object domain and range information, data properties domain information, individual class assertion information and related SWRL rules changes.

2.3 Role Based Ontology Collaborative Definition

There are ordinary users, system administrators and domain experts as three kinds of roles in the system. Role based ontology collaboration definition is shown in Fig. 4. Ordinary users can learn or reuse ontology from the system. A new domain ontology

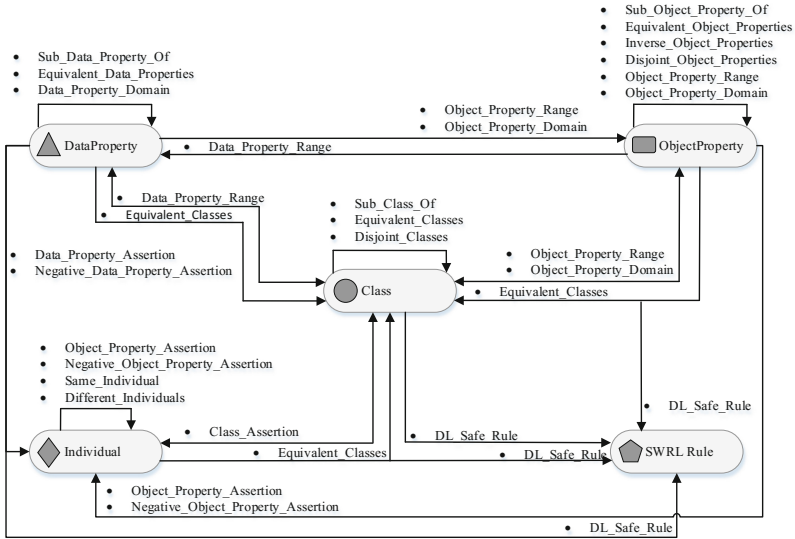


Fig. 3. The relationship of resources in ontology

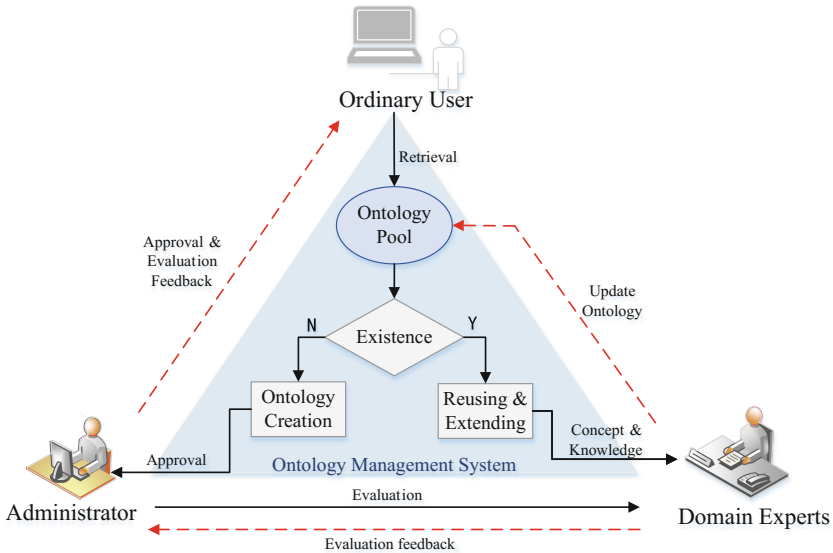


Fig. 4. Role based collaborative definition

can be created by ordinary users and then evaluated by the domain experts. After being audited by field experts, the created domain ontology will be incorporated into the system. The system administrator is a business maintenance person who is responsible

for handling the response from the user or domain expert in the system. Domain experts are the defenders of ontology knowledge, who is responsible for the evaluation of the domain knowledge of user expansion.

- Ordinary users can search each domain ontology in the ontology pool of the system. Otherwise, they can create a new field in the system, and wait for the feedback of the rationality of this ontology by system administrators and experts in the field; if a domain ontology can be queried, it can be directly reused in the system. But the user has no authority to modify the ontology in the system.
- The system administrator is responsible for the approval of ordinary users because they do not search the desired ontology and create their own ontology information. After being approved through examination, the approval information will be fed back to users. At the same time, the ontology will be transferred to experts in the field to be evaluated. Finally the administrator receives the experts' feedback on the rationality of new domain ontology and accordingly gives feedback to ordinary users.
- Domain experts are responsible for the control of the correctness of the system ontology concepts and rules. On one hand, they receive the concepts and rules of the extension of the user in a certain field, and verify its reasonableness after determining whether to update the domain ontology. On the other hand, experts evaluate users' newly created ontology that not exist in the system, and give the evaluation feedback to determine whether the ontology should be added to the system ontology pool.

Role based ontology collaboration definition can ensure the correctness of the ontology description of the knowledge in the system. Ordinary users, system administrators and experts in the field use ontology management system based on Web, collaboratively maintain ontology which makes the ontology expression knowledge richer and it is conducive to the development of each domain ontology.

3 Ontology Reuse in Web Environment

Ontology is a kind of method used to describe knowledge. Rule can be used as a means to express knowledge when the concept of ontology is unified. Being a language which presents rules in the semantic way, SWRL provides the expression ability which is not allowable by OWL while maintaining compatibility with syntax, semantics, and theoretical model of OWL. Therefore, an ontology reuse method based on SWRL rule is proposed by the concept unification in this paper.

3.1 Unification of Ontology Concept

The concept of ontology refers to the class, object property and data property of it. If the name of the concept and its properties are in conformity with the things that are described in the field of application, then the existing concepts can be considered to be completely consistent with the concept of application domain description.

There are four kinds of situations in the process of the unification of ontology concept:

- (1) The described concept exists in the existing ontology, and it is completely consistent with the concept described in application domain.
- (2) There are similar concepts in the existing ontology, only its name is inconsistent with the description of the application domain. Other properties are exactly the same.
- (3) There are similar concepts in the existing ontology, its name is consistent with the description of the application domain. But its properties are not.
- (4) The described concept does not exist in the existing ontology, both its name and properties cannot match the description of application domain.

For case (1), new concepts do not need to be given to original ontology while it is applied. For case (2), different nouns are used to describe the same thing in different domains. So owl: euivalentClass, owl: equivalentObjectPropert or owl: equivalentDataProperty will be used to declare that the new concept is equivalent to the existing concept description when new concepts are added. For case (3), the name of new concept adopts the naming rules of “similar concept name + suffix” to add the properties of application domain described concept. For case (4), a new concept has to be added.

3.2 Rule Based Ontology Reuse

SWRL rules specify a conjunction of facts. If the rules are met, another collection of facts is contained. SWRL rules are mainly composed of two parts: Head and Body. Head represents the conclusion of the rule while Body represents the premise. Head and Body are made up of zero or more atoms. The type of atom might be: class element, relationship element between class and class, relationship element between class and data, type element of variable, equivalent element, non-equivalent element and built-in element.

The type of atoms is defined as follows:

- Class element - $C(?c)$, which represents an individual variable c that belongs to class C .
- Relationship element between class and class - $P(?c_1, ?c_2)$, which denotes that the individual c_1 and the individual c_2 that has a relation, that is, property P .
- Relationship element between class and data - $R(?c, ?v)$, which denotes that individual c has relation of property R with the literal value V .
- Type element of variable - $D(?t, ?v)$, which denotes that the data type of literal variable V is t .
- Equivalent element - $SA (?c_1, ?c_2)$, which denotes that individual c_1 is equivalent to individual c_2 .
- Non-equivalent element - $DF (?c_1, ?c_2)$, which denotes that individual c_1 is not equivalent to individual c_2 .

- Built-ins element - BI ($?x, ?y$), which denotes that variable x and variable y have certain kind of function relation.

Based on the definition above, SWRL rule could contain zero or more atoms for each type of atoms. As a result, Head or Body can be expressed as:

$$\{C, P, R, D, SA, DF, BI\} \quad (1)$$

Ontology reuse based on SWRL rules is built on the basis of a unified understanding of described concept and sharing the same ontology to express new knowledge by rules. For example, a knowledge in the field of tolerance: A cylindrical feature is marked with a cylindrical tolerance, with a tolerance grade as "IT7" and diameter t of the cylinder. When $250\text{mm} < t \leq 400\text{mm}$, cylindrical tolerance value of this cylindrical feature is 0.014 mm. When the concepts, such as cylindrical feature, tolerance grade, tolerance type, etc. are unified, this piece of knowledge will be represented by the SWRL rule as: `Cylinder_Feature (?x), Cylindrical_Tolerance (?y), has_ToleranceType (?x, ?y), has_ToleranceGrade (?x, "IT7"^^String), has_MainSize (?x, ?value), greaterThan (?value, 250.0f), lessThanOrEqual (?value, 400.0f) → has_ToleranceValue (?x, 0.014f)`.

When various fields share one ontology from the beginning and concepts of this field are unified, domain knowledge can be expressed with SWRL rules. In the end, reuse of ontology can be achieved without information alignment process between two ontologies.

4 Conclusions

Ontology management and ontology reuse play a vital role in the ontology application. This paper builds an ontology management system based on role collaboration definition, and puts forward a SWRL-based ontology reuse method. Each domain ontology is constantly developed under the premise of cognitive unification of domain experts, and the efficiency of ontology construction is greatly improved.

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